

# OBJECTIVE MEASUREMENTS OF FRENCH FRIED POTATO QUALITY. LABORATORY TECHNIQUES FOR RESEARCH USE<sup>1</sup>

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## ABSTRACT

Processing French fried potatoes on a laboratory scale presents many problems. These problems involve sampling, elimination of variables such as those due to specific gravity, freezing, and frozen storage. Techniques are presented for sampling, slicing, blanching, frying, agitation, draining, freezing, elimination of sublimation in storage and reheating. In order to prevent degradation of texture resulting from slow freezing, a simplified liquid nitrogen freezer was constructed. Modifications were made on a standard, electronic, recording shear press to increase its suitability for objective texture studies and interpretation of the results. A standardized method for use of this modified shear press is described in detail for research evaluation of French fry texture.

## RESUMEN

Investigando papas fritas a la francesa en el laboratorio presenta muchos problemas. Estos problemas conciernen como obtener muestras, la eliminación de variables como las debidas a la gravedad específica, el congelamiento y el almacenaje congelado. Se presentan técnicas para obtener muestras, rebanar, blanquear a miento freír, agitación, drenaje, congelamiento, eliminación de la sublimación durante el almacenamiento y recalentamiento. Para prevenir la degradación de textura resultante de un congelamiento lento, se construyó un modificado congelador con nitrógeno líquido. Se han hecho modificaciones en una normal prensa cortadora electrónica para aumentar su conveniencia para estudios objetivos de textura e interpretación de resultados. Se describe en detalle un método estandarizado para el uso de esta prensa cortadora con el propósito de la evaluación de la investigación de la textura de las papas fritas a la francesa.

Manufacturers of frozen French fried potatoes purchase large quantities of raw material of essentially uncertain processability. Subjective testing of the finished product requires the use of a relatively large number of man-hours and produces results which, for many purposes, are of doubtful accuracy. A research project at this laboratory is aimed at the improvement of quality, development of simple objective methods of quality control for this purpose, and the establishment of a method of quality prediction from tests on raw, unprocessed potatoes and/or freshly fried potatoes.

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Many attempts have been made to develop replacements for subjective evaluation for application to various food products (2) and instruments such as the Tenderometer, Durometer, Christel Texturometer, Magnus-Taylor Pressure Tester, Denturometer, Chatillon Compression Tester, Maturometer, Morris Puncture Tester, and the Shear Press were designed and tested. Of these instruments, the shear press appears to be the most satisfactory for quality evaluation of French fries.

The purpose of this paper is to discuss problems encountered during these investigations and to describe the solutions of them.

#### MATERIALS AND METHODS

Russet Burbank potatoes, grown in Idaho in the same area each year, were used for these studies. After harvest, the tubers were shipped with maximum protection from mechanical damage and temperature extremes. At the laboratory they were stored at 50 F and 85-87% relative humidity in burlap bags, spaced for good air circulation to minimize specific gravity changes.

Figs. 1-3 show three general views of the laboratory and the equipment employed. Fig. 1 indicates the arrangement for sample slicing and blanching. Fig. 2 depicts the deep fat fryer, the liquid nitrogen freezing equipment and the reheating oven. In Fig. 3 are shown the apparatus for specific gravity determination, the electric freezer, and the shear press with its amplifier and recorder.

The potato samples were separated into specific gravity groups differing by 0.005 units. Each individual tuber was numbered by use of a coarse felt-tipped pen and then weighed in air and in water (60 F) using a Mettler K7 balance<sup>3</sup> equipped with an accessory sample hook from which a wire basket was suspended. The tubers were cut to  $2\frac{5}{8}$  inch lengths (to fit the standard shearing cell) with a double knife cutter shown in Fig. 1. A  $\frac{3}{8}$ -inch cutter was used in the French fry slicer. To reduce the number of variables, only perfectly rectangular shaped slices were used. All slices were selected from the same percentage distance from the tuber center, preferably half way, and tubers of as near equal size as possible were used.

To obtain reproducible blanching, the tubers were brought to room temperature before slicing. Batches of 400 g were placed in 5 liters of water in a home-made blancher. This apparatus was made from two 5-liter stainless steel beakers with different diameters. The inner beaker had sixteen  $\frac{3}{8}$  inch diameter holes in the bottom of two upright handles. The water was heated to 185 F in a Chromalox<sup>3</sup> 2000 watt hotplate set at low heat. Introduction of the 400 g sample caused the temperature to drop to the required 175 F and heating was continued for 6 min. The sample was stirred once per minute by slowly lifting the inner beaker and then releasing it. After blanching, the slices were drained for one minute in the fry basket to prevent spattering in the fryer.

A standard type 15-lb fat capacity, 4500 watt, electric fryer at 365 F was employed for frying. During the 3 min fry, the fry basket was shaken, once per minute, to agitate the pieces. After frying, the fry basket was bounced five times on a heavy board to remove excess fat. Lever Brothers "Covo"<sup>3</sup> brand vegetable shortening (9) was employed.

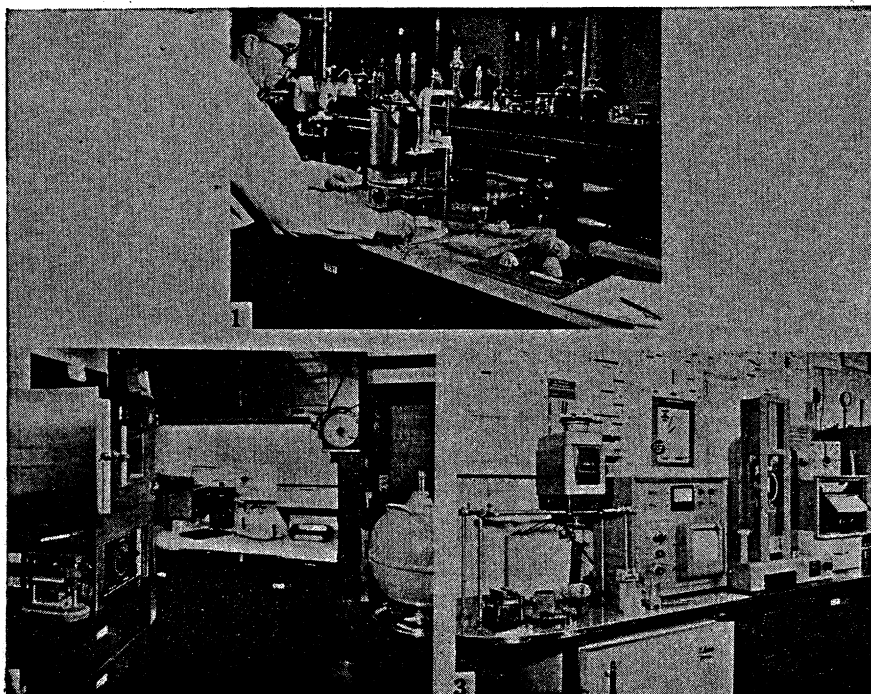


FIG. 1.—Sample preparation and blanching apparatus.

FIG. 2.—Frying, liquid nitrogen freezing and reheating apparatus.

FIG. 3.—Specific gravity apparatus, frozen storage and shear amplifier, press and recorder.

To produce consistent texture results, the fried slices were frozen rapidly. To accomplish this, a simple liquid nitrogen freezer was developed. It consisted of a wooden draft shield, a liquid nitrogen tray, and a 0.5 inch mesh, silicone treated screen tray to support the slices. The assembly is shown, with the draft shield raised for illustrative purposes, at the right of Fig. 2. Immersion of the slices directly in the liquid nitrogen freezes the slices too rapidly and cracks form on the surface. This was eliminated by use of the screen tray supported one inch above the liquid nitrogen surface. About 3 liters of liquid nitrogen were required. Hot slices, direct from the fryer, were frozen in about 10 min and then were packaged for frozen storage.

The frozen slices were placed in labeled, double polyethylene bags. The bags were partially evacuated and sealed by tying in a knot. These were placed in standard freezer cartons or double paper bags and placed for storage on shelves made of wire mesh supported 2 inches above the freezer shelves.

To simulate home reheating, a 14 inch x 14 inch x 14 inch, 1500 watt gravity convection oven was employed. Frozen slices were placed, in a single layer, on a plain, silicone treated, stainless steel tray which was then put in the center of the top shelf of the oven where the temperature

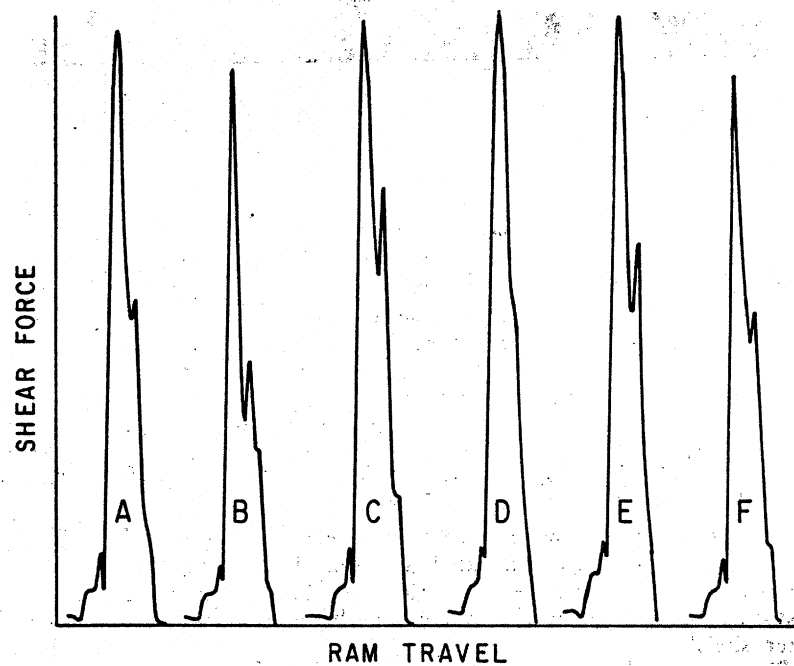
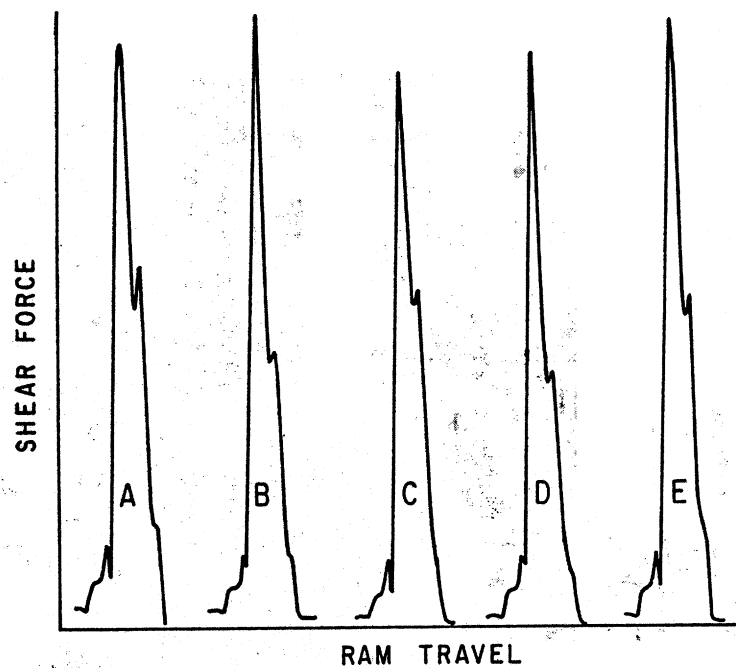


FIG. 4A.—Variety variables in French fry shear force curves in potatoes grown in Idaho: A. Cobbler. B. Katahdin. C. Kennebec. D. Pontiac. E. Russet.  
FIG. 4B.—Source variables in shear force curves from French fried Russet Burbank potatoes: A. Idaho. B. Maine. C. New York. D. Pennsylvania. E. Red River Valley. F. Wisconsin.

was most constant. Reheating was continued for 20 min at 425 F. Shear determinations were started 45 sec after removal from the oven. Both reheating and cooling intervals (for shear force vs cooling time) were timed by two electric clocks connected in series.

The shear force determinations were made using the modified equipment described in a previous paper (9). It should be noted that, due to the design of the recorder, zero time or zero ram travel is on the right of each individual plot and the curve must therefore be read from right to left.

### RESULTS AND DISCUSSION

The materials and methods described are the result of a gradual development of techniques. The samples employed were selected because variety and location of growth have a definite effect on the French fry shear force curve (Fig. 4A, 4B). These effects are usually more apparent qualitatively, in the shape of the curve, rather than quantitatively, in the area under the curve or the maximum shear force required. Therefore, to limit the variable to be considered, one variety from one area of growth was selected for the major portion of the work.

The conditions of storage were selected to minimize the possibility of changes in specific gravity because of the sensitivity of the shear force method to specific gravity. Fig. 5 shows the relationship of maximum shear force of raw slices to the specific gravity of the raw tuber. It is apparent that differences of 0.005 specific gravity units can be detected. The maximum deviation from the mean for the replicates for each point was  $\pm 0.35$  pounds. A similar relationship has been noted for fried, frozen, and reheated slices but the deviation from the mean for these analyses was so large as to vitiate the conclusions. The difference in the deviations from the means is due to the inherent physical changes caused by frying, freezing, storage, and reheating. To obtain a sensitivity of 0.005 specific gravity units for stored and reheated samples further work must be carried out.

Again, to reduce the number of variables, only perfectly rectangular slices were used. Tapered ends, pieces of skin, hollow heart, cracks, and other defects have proven to adversely affect the shear relationship (7). Outer slices exhibit a different shear force than inner slices, probably because they consist of skin and cortex tissue (Fig. 6). A higher solids content, due to moisture loss during handling and storage, may also play a part. Therefore, all slices were selected so that none of the center tissue or of the outer tissue was employed. These pieces consisted of tissue from about one-half way between the center and the skin of the tubers. Since tubers of nearly equal size were used, this technique gave as near to duplication of tissue as possible.

Freezing equipment comparable with that used commercially is not available in the laboratory. Attempts to stimulate samples produced commercially by directly freezing the French fry strips in a household freezer were unsuccessful due to the magnitude of the deviations from the mean of shear force results made on replicate samples. The cause of this uncontrollable variation can be traced to the slow and variable rate of freezing and the consequential changes in the physical structure of the

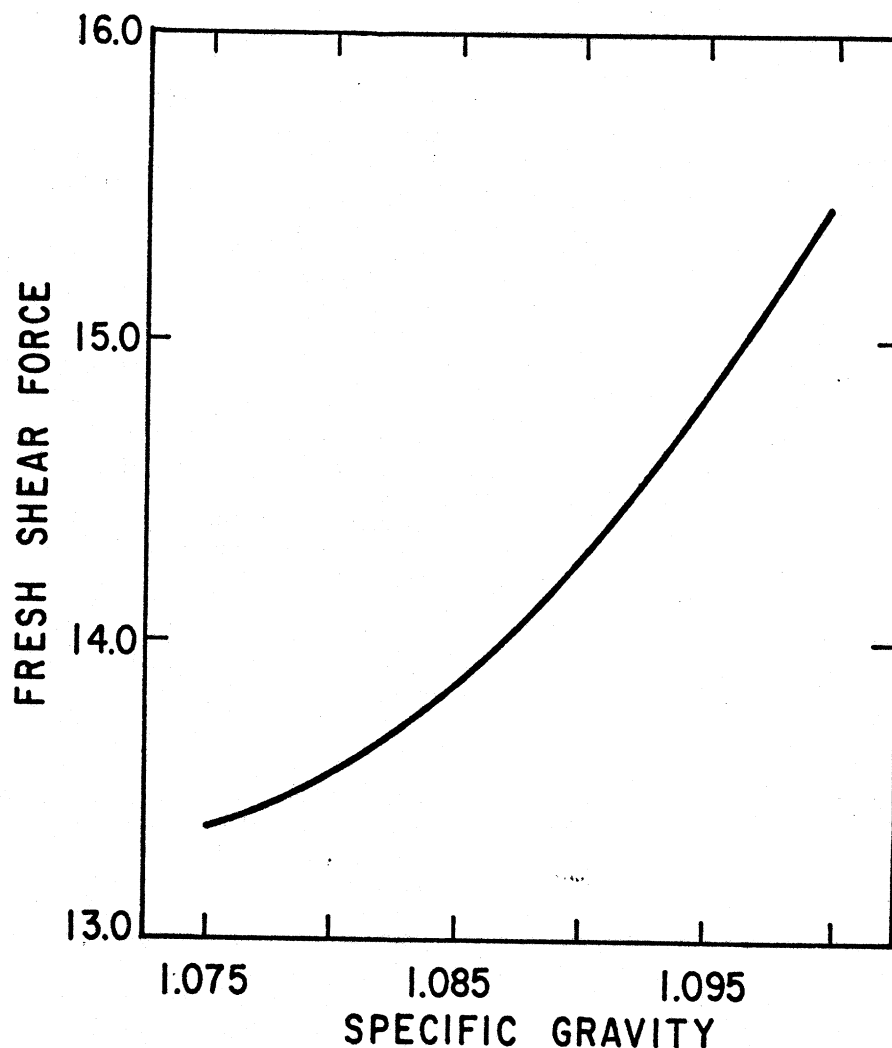


FIG. 5.—Specific gravity effect on shear values of raw potatoes.

samples (5). The liquid nitrogen method finally adopted, does not eliminate all variables causing deviations but it does not introduce new variations in the sample to the same extent as the electric freezer. As a result, deviations from the average curve (shear force vs cooling time, for example) can usually be traced to some other cause, such as small bits of skin, excess moisture in one part of the reheating tray or excessive drying of some slices. For these reasons, the liquid nitrogen method was selected for these studies.

When frozen slices, in polyethylene bags, are placed directly on the freezer shelves equipped with cooling coils, sublimation of water takes place in a short time and a snowy form of ice crystals collect in the bag.

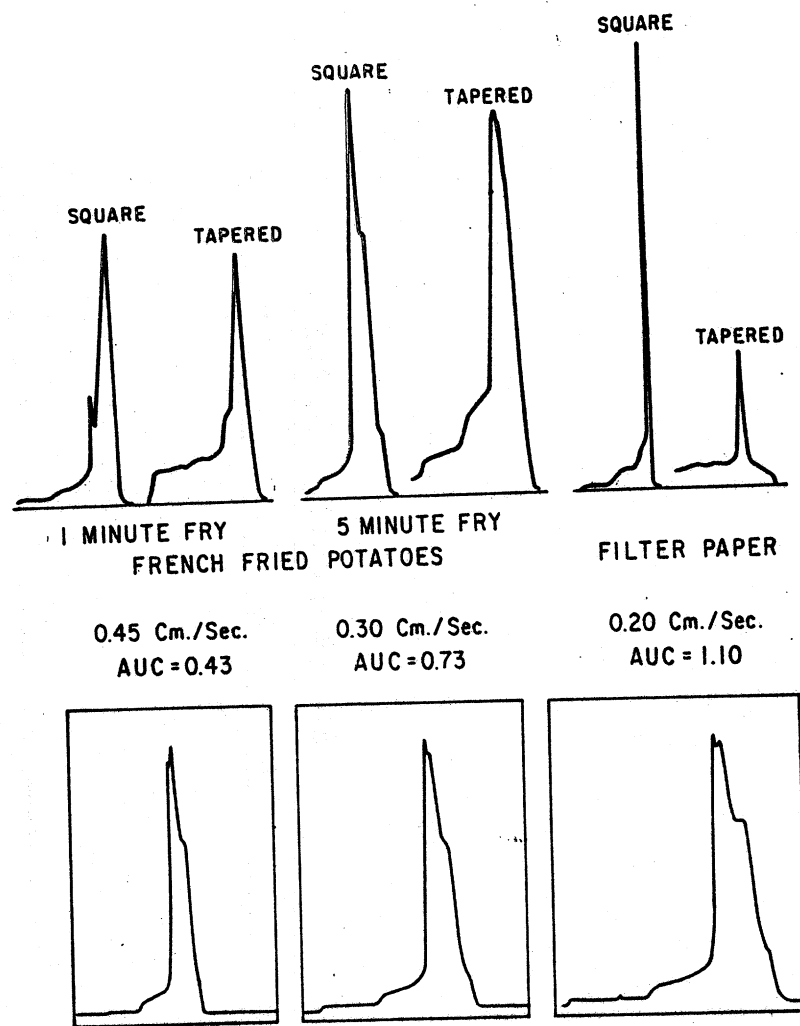


FIG. 7.—Effect of shear test cell movable blade bottom shape on French fries and filter paper.

FIG. 8.—Ram speed effect on French fried potato shear force curves.

in several bags, and installation of shelves above the freezer shelves. These changes in freezing, packaging and storage methods were made to produce uniformity for research purposes. Inclusion of such refinements in a recommended objective testing system is not contemplated.

One of the changes made in the shear press equipment was the use of square leading edges on the movable blades of the test cell in place of the tapered type routinely furnished by the manufacturer (8). These latter blades were cut at about  $2.5^\circ$  angle, when viewed from the wide side of the blade. The direction of the taper was alternated for

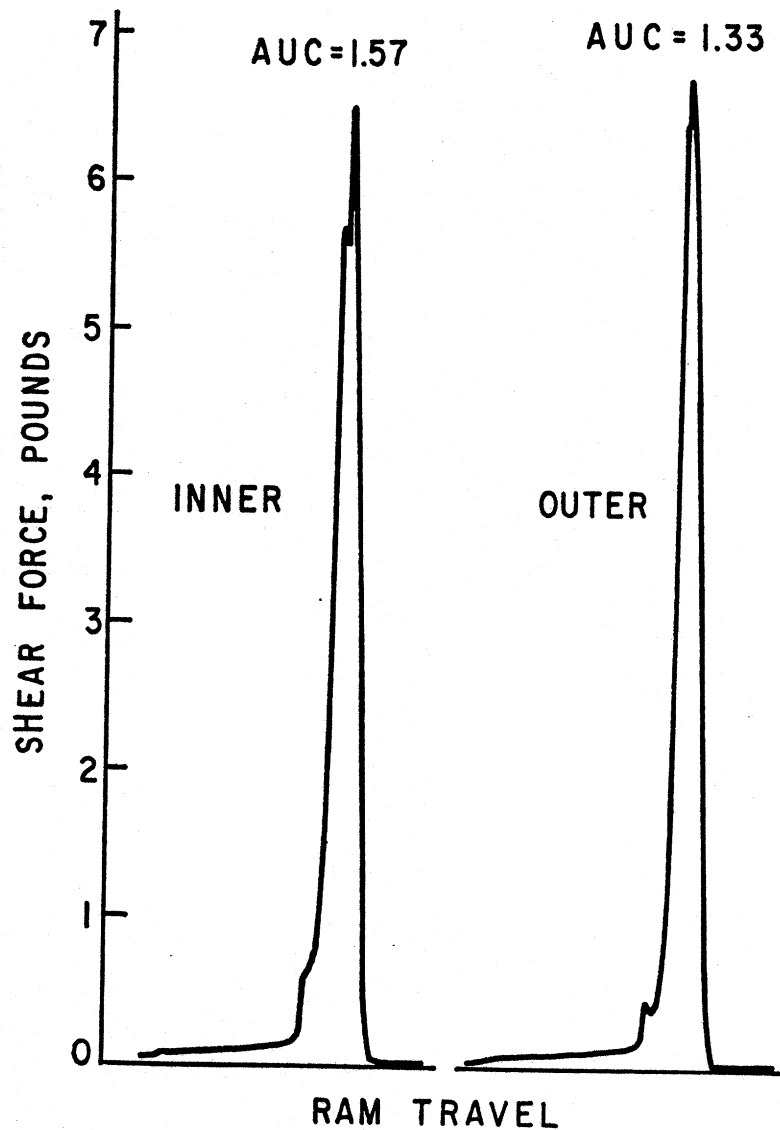


FIG. 6.—Shear force curves from raw potato slices from the tuber center and periphery.

Under these conditions, uniform reheating is impossible because the ice melts and the liquid runs to the bottom of the tray and usually to one corner. Therefore, some slices were soggy while others became too dry. It was found that, if the already frozen slices could be insulated from temperature changes, sublimation, condensation and refreezing of this water was prevented. This was accomplished by the techniques described previously which consisted of prefreezing before putting in storage, placing

each of the ten blades. These blades were apparently designed for samples, such as meat, which require a greater force for shearing and cause the various events, in the shear force curve of a multitextured food, to overlap and to have less detail (Fig. 7). Periodically the shear press system is checked for overall reproducibility by the filter paper method of Binder and Rockland (1), also indicated in Fig. 7.

Ram speed must be perfectly controlled and selected to obtain the greatest amount of information. A comparison of the difference in detail caused by variation in the rate of shearing is shown in Fig. 8. As ram speed was decreased, the area under the curve increased logarithmically and fine detail became more apparent. The slower ram speed results in a broader curve since the recorder is time based.

Further work on use of experimental cells (3) stress relaxation (4) and determination of mechanical properties (6) as related to quality of French fried potatoes is in progress.

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